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Scientific Work

1. As a Student, 1913-18

Collision of electrons with molecules

Conduction of electricity through gases

2. At Laboratory of Electronic Phenomena, 1920-26

a. Electric Fields

Collaborated with G. A. Grinberg, V. M. Kudryatseva, Val'ter

(1) Passage of electric current through gases

(2) Electric spark-over in vacuum

(3) Heat theory of breakdown of solid dielectrics

b. Molecular Physics

Collaborated with P. D. Dankov, Ya. I. Frenkel', P. L. Kapitsa,
Yu. B. Khariton, S. Z. Roginskiy, A. I. Shal'nikov

Molecular beams

Preparation of stable sols of the alkali metals

c. Electronic Phenomena

Collaborated with V. N. Kondrat'yev, A. I. Leypunskiy

Molecular dynamics

Dissociation of salt vapors under electronic bombardment

3. In Physicochemical Division, 1927-31

Collaborated with N. M. Chirkov, Yu. B. Khariton, A. A. Koval'skiy,
A. B. Nalbandyna, M. B. Neyman, Ryabinin, P. A. Sadov'nikov, O. M. Todes, Val'-
ter, A. V. Zagulin

Oxidation of phosphorus vapor at low pressures

Oxidation of sulfur vapor

Oxidation of Co, H₂S, CS₂, COS, CH₄, etc.

4. At Institute of Chemical Physics, 1931-46

a. Work of Institute as a Whole

From the beginning there have been five clearly defined divisions P.
in the work of the institute. They are:(1) Chemical Kinetics (Corresponding Member V. N. Kondrat'yev and
Academician N. N. Semenov)

(2) Theory of Combustion (Professor Ya. B. Zel'dovich)

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- (3) Theory of Catalysis (Corresponding Member S. Z. Roginskiy)
- (4) Mechanism of Combustion and Detonation of Explosive Substances (Professor Yu. B. Khariton)
- (5) Theory of Combustion in Engines (Professor A. S. Sokolik)
- b. Investigations Initiated and Carried Out Primarily by Semenov
 - Collaborated with D. S. Davlov, N. M. Emanuel, D. A. Frank-Kamenetskiy, Shantarovich, O. M. Toes, V. G. Voronkova, Ya. B. Zel'dovich
 - (1) Oxidation of arsine
 - (2) Cold flames
 - (3) Oxidation of hydrogen sulfide
 - (4) Relation between spontaneous combustion pressure and temperature
 - (5) Book Tsepnyye Reaktsii (Chain Reactions) (Praised by such scientists as M. Bodenstein, C. N. Hinshelwood, G. V. Kistjakovskiy, H. S. Taylor, H. C. Urey)
 - (6) Criterion for establishing extent of a chain reaction

Administrative Work

- 1920-29 Assisted A. F. Ioffe to organize Physicotechnical Institutes at Tomsk, Khar'kov, and Dnepropetrovsk
- 1929 Made arrangements for first Physicochemical Conference, in conjunction with A. N. Frumkin, I. A. Kazarnovskiy, and A. I. Rabinovich
- 1930 Special conference to study kinetics of chain reactions
- Cofounder of Zhurnal Fizicheskoy Khimii
- 1933 Cofounder of Acta Physicochimica URSS

Educational Work

- 1920-24 Assistant at Leningrad University
- 1924-29 Docent at Leningrad University
- 1944 Organized Chair of Chemical Kinetics at Moscow State University

N. N. Semenov began his scientific work during his second year at Petrograd University. His first independent work, published in 1916, dealt with an analysis of the collision of electrons with molecules.

After graduating from the university, he devoted himself entirely to scientific, pedagogical, and organizational work.

In 1920, he began to work at the Physicotechnical Institute, headed by Academician A. F. Ioffe, and was one of the latter's closest assistants. The electron phenomena laboratory, which was under Semenov's supervision, originally

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worked on electron fields, molecular physics, and electron phenomena. The first of these fields, together with theoretical questions, encompassed problems of practical importance (electrical research, the theory and the testing of electrical cables and insulators).

Semenov's main interest in that period was the thermal basis of the theory of dielectric breakdown. This theory turned out to be very important from the viewpoint of application of its basic idea to the study of combustion phenomena (thermal theory of explosion).

In the field of molecular physics, Semenov and his coworkers conducted a series of interesting studies of the molecular beam (a ray of molecules moving in a high vacuum in a definite direction). The investigation of the molecular beam permitted determination of atomic and molecular constants and study of the mechanism of concentration and the growth of crystals.

The work in the field of electronic phenomena turned out to be a step into the field of chemical processes. In 1924, the article "Chemistry and Electron Phenomena" was published. Without mentioning the value of the factual material, the article is of interest because of the way in which the problem is formulated. In addition to an analysis of the experimental data of foreign scientists, it contained results obtained in Semenov's laboratory. Great attention was given to the investigation of the ionization potentials of vapors of salts, to the investigation of metal vapors, and later to the reactions of excited vapors.

In 1926, Semenov published a short memorandum "On Some Chemical Reactions." One of the experiments (investigation of the oxidation of phosphorus vapors) written up in this memorandum became decisive in the development of Semenov's ideas on chemistry.

Subsequently, Semenov investigated the detailed mechanism of chemical conversions. Thus, many ideas he developed in the investigations of phenomena generally called physical proved to be very fruitful in the study of chemical conversions.

The critical phenomena discovered in his laboratory in 1926-27 and investigated by him in detail on the example of the oxidation of phosphorus vapor, were interpreted from the theoretical standpoint by Semenov. On this basis he advanced a mechanism of reaction, explaining the phenomenon of the lower limit. Later critical phenomena were discovered in the oxidation of sulfur vapor, and subsequently in many other explosive reactions. His work "Contributions to the Theory of Combustion Processes" (1928) appeared only 2 years after his first experiments. In this work he formulated in perfect clarity the theory of thermal explosion and of chain ignition connected with the self-acceleration of the reaction as a result of the branching of chains.

Thus were created these important and now widely known theories of complicated and until then puzzling chemical phenomena.

The laboratory, and later the physicochemical department which had initiated an independent original trend, was suffering from lack of space in the Physicotechnical Institute, and in 1931 it was made into the independent Institute of Chemical Physics, headed by Semenov. In 1932, Semenov received the first great recognition for his scientific achievements; the Academy of Sciences appointed him an active member.

In the following years, Semenov and his school began to develop chemical kinetics from a chapter in physical chemistry into a separate science, in

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Semenov's words, "the science of the chemical process, encompassing, on the basis of chemico-physical theoretical analysis, the totality of the processes of organic and inorganic chemistry."

In chemical kinetics, the following theories are connected with the name of Semenov: branched chain reactions, breaking of the chains on the walls of the reaction vessel, interaction of chains, and thermal explosion.

In 1934, Semenov's important monograph *Tsepnyye Reaktsii* (Chain Reactions) appeared. (It was published in English in 1935 by the Oxford Clarendon Press). In this book he set forth in detail the theoretical foundations of the chain theory and analyzed and creatively elaborated all experimental and theoretical material (about 320 experiments) from the standpoint of kinetics of chemical transformations of the chain character.

Starting at this time, Semenov and his many students developed the theories of chemical reactions and combustion. He re-examined the older theory of chemical reactions based on probability and replaced it by an analysis of the kinetics of complex reactions based directly on the observation of their elementary stages. The chain theory of one active center was generalized for the case of many active centers. On the basis of the analysis of kinetics of reactions in flames, the chain mechanism of reaction was introduced into the schematic thermal theory of combustion.

In 1931, on this scientific basis, the theory of flame propagation, the theory of detonation and of combustion of explosive matter and powders, the theory of combustion in internal-combustion engines, and others, were developed at the institute. The lines of research pursued by Semenov's pupils, Professors Khariton, Sokolik, and Zel'dovich, made the institute the leading center of physics of combustion and explosion.

New experimental facts were obtained by Semenov's pupil, V. N. Kondrat'ev, corresponding member of the Academy of Sciences USSR, demonstrating the decisive role played by free radicals, atoms, and other active particles in the occurrence of a chain reaction.

New methods were developed for the study of intermediate products of complex chemical reactions. The conclusions of the theory are used in various laboratories of the institute for the improvement of combustion and explosion processes in technology.

S. Z. Roginskiy, corresponding member of the Academy of Sciences USSR, worked at the institute from 1928 to 1942. His outstanding work in the field of heterogeneous catalysis was pursued in close contact with the general ideas on kinetics of Semenov. The laboratories of the Institute of Chemical Physics are staffed and run by many of Semenov's pupils. In 1941, Semenov was awarded the Stalin First Prize for his outstanding work in the field of chemistry.

In 1920, Semenov began his pedagogical activity. He was closely connected with the Physicomechanical Faculty of Leningrad Polytechnic Institute. On his initiative, a department of chemical physics was set up there in 1930. Semenov personally took an active part in organizing the physicochemical sections, suggesting qualitative selection of students for the research institutes, with an aim toward the best organized use of science for improving production. Semenov conducted several courses (general physics, molecular physics, electron phenomena). Some of his lectures were published in book form.

Semenov showed energetic scientific organizational activity from the moment of his graduation from the university. As assistant to Academician A. F. Ioffe, he actively organized the Physicotechnical Institute and the Physico-technical Laboratory at the Supreme Council of National Economy. Together with

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Ioffe, he took part in the founding of the Physicotechnical Institutes at Tomsk, Khar'kov, and Dnepropetrovsk. Founding the Institute of Chemical Physics, he contributed greatly to the advancement of the educational system for engineer-physicists and the creation of cadres of highly qualified research engineers. As one of the members of the organizing committee of the physicochemical conferences, he worked actively on their organization. Since 1927, nine conferences have been held. The Sixth Physicochemical Conference (1930) was devoted to the kinetics of chain reactions.

Semenov is one of the founders of the periodical Zhurnal Fizicheskoy Khimii (1930) and of the Acta Physiochimica URSS (1933).

Devotion to science, a wide scientific range, the ability to chart the principal line of research, initiative, and a talent for organization characterize Semenov, a true scientific researcher.

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